

LIQUID STORAGE CONTAINER, AND LIQUID DISCHARGE  
RECORDING APPARATUS USING THE CONTAINER

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a replaceable liquid storage container suitable for the use in an ink jet recording apparatus, or the like, and a liquid discharge recording apparatus using the  
10 container. Specifically, it relates to a liquid storage container for storing a dispersion type ink (liquid) such as a pigment, and a liquid discharge recording apparatus using the container.

Related Background Art

15 The ink jet recording method is for executing a desired recording operation by jumping ink droplets from a minute ejection opening provided in an ink jet head, and having the ink droplets impact on a recording medium.

20 As an ink used for the ink jet recording, a liquid using a dye has mainly been used. However, according to a recorded matter recorded with a liquid using a dye, the performance required for the applications regarding the light resistance and the  
25 weather resistance important, such as the exterior display printed matter, or the like cannot be provided, and thus a liquid using a pigment is used

instead thereof.

Since the pigment is not a dissolution type but a dispersion type, according to an ink (liquid) using a pigment, pigment particles are precipitated in an  
5 ink tank as a liquid storage part.

In the case of an out carriage tank with an ink tank fixed statically (such as a main tank used for a recording apparatus disclosed in the specification of the U. S. Patent Application Disclosure No.  
10 2002/109758, or the like), it has been revealed that the pigment precipitation phenomenon cannot be ignored depending on the use frequency, the use interval, the number of recording (number of recorded sheets), or the like of the recording apparatus.  
15 Particularly in the case of the out carriage tank, the ink capacity tends to be made larger for the purpose of reducing the replacement frequency of the ink tank as the liquid storage container for the user with the need of high user frequency. Also in this  
20 regard, there has been the concern about the pigment precipitation not to be ignorable for the user.

For example, in the case the ink tank is left for a long time in a state mounted on the ink jet recording apparatus, the pigment particles are  
25 gradually precipitated inside the ink tank. As a result, the density inclination of the pigment particles is generated from the bottom part to the

upper part inside the ink tank (liquid storage container) so that a layer with a high pigment particle density having an excessively thick color is generated in the bottom part, and a layer with a low  
5 pigment density having an excessively thin color is generated in the upper part.

Then, in the case an ink is supplied from the ink tank having a configuration of guiding out the ink in the ink storage chamber from the ink tank  
10 bottom part, since the ink is supplied first from the layer with the high pigment particle density, a problem (technological task) is involved in that a printed matter with an excessively thick color is produced, and then the density difference to the  
15 degree visually recognizable is generated in the printed matters between the use initial stage and the use latter stage of the ink tank. This phenomenon becomes particularly remarkable in the color printing for providing an image by the color thickness.

20 In order to solve the technological task, for example, as it is disclosed in the Japanese Patent Application Laid Open (JP-A) Nos. 2001-270131 and 2001-293880, a tube-like pipe with a plurality of holes is provided in an ink tank from the ink supply  
25 opening of the ink tank so that the ink is vacuumed not only from the part in the vicinity of the ink supply opening inside the ink tank but also from a

large number of portions in the vertical direction in the ink tank, wherein a portion for temporarily storing the ink vacuumed from the large number of the portions is provided such that the density  
5 irregularity of the ink in the vertical direction being left for a long time in the ink tank can be alleviated by supplying the ink from the storing portion.

However, since the relationship with respect to  
10 the pigment precipitation characteristic is not taken into consideration in the holes provided in the tube-like pipe of the ink tank disclosed in the above-mentioned Japanese Patent Application Laid-Open (JP-A) Nos. 2001-270131 and 2001-293880, the density and  
15 the mount of the ink flown in from the outside of the tube-like pipe through the holes provided in the tube-like pipe are not administered so that the ink density in the tube-like pipe becomes consequently different from the original ink density, and thus the  
20 problem of generation of the density difference in the recorded matters in the use initial stage and the use latter stage of the ink tank had not been solved sufficiently.

Moreover, as means for solving the coloring  
25 material precipitation, there is a method of providing propeller-like agitating means and driving means for rotating the same inside a main tank for

rotating the agitating means regularly at a predetermined rate. However, the agitating mechanism is extremely expensive. Moreover, in the case the driving means (motor) is provided in the vicinity of an ink channel, a leaked ink adhered on a power source connector part of the driving motor can be the cause of breakdown such as short circuit so that there is the risk of leading to generation of smoke, fire, or the like.

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#### SUMMARY OF THE INVENTION

The present invention has been achieved in order to solve the above-mentioned conventional problems, and an object thereof is to provide a liquid storage container for storing a liquid containing a content such as a pigment as a coloring agent, capable of maintaining the density of the liquid to be taken out at a value close to the initial density even in the case the content is precipitated according to the time passage, and capable of maintaining a predetermined recording density by preventing the density variance of the recorded matter even in the case of use over a long term in a recording apparatus, or the like, and a recording apparatus using the storage container.

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In order to achieve the above-mentioned object, a liquid storage container according to the present

invention comprises a liquid storage part for storing a liquid, a connection part for taking out the liquid, provided in the bottom part of the liquid storage part, and a pipe provided in the liquid storage part so as to cover the opening of the connection part on the liquid storage part side, wherein a plurality of liquid inlet holes are formed in the pipe, each communicating with the liquid storage part at a plurality of positions in the vertical direction, and the inlet resistance of the liquid inlet holes disposed in the lower layer area on the bottom part side out of the plurality of the liquid inlet holes of the pipe is larger than the inlet resistance of the other liquid inlet holes.

Moreover, a liquid storage container of another aspect of the present invention comprises a liquid storage part for storing a liquid, a connection part for taking out the liquid, provided in the bottom part of the liquid storage part, and a pipe provided in the liquid storage part so as to cover the opening of the connection part on the liquid storage part side, wherein a plurality of liquid inlet holes are formed in the pipe, each communicating with the liquid storage part at a plurality of positions in the vertical direction, and the hole diameter of the plurality of the liquid inlet holes of the pipe is set such that the liquid inlet amount from each inlet

hole into the pipe becomes substantially equal.

According to the above-mentioned liquid storage container, a liquid storage container for storing a liquid containing a content such as a pigment as a coloring agent, capable of maintaining the density of the liquid to be taken out at a value close to the initial density even in the case the content is precipitated according to the time passage, and capable of maintaining a predetermined recording density by preventing the density variance of the recorded matter even in the case of use over a long term in a recording apparatus, or the like, and a recording apparatus using the storage container, can be provided.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing a liquid discharge recording apparatus capable of adopting the present invention.

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FIG. 2A is a schematic diagram showing the schematic configuration of an ink supply system in the case of using a first embodiment of a liquid storage container adopting the present invention as the ink tank of the ink jet recording apparatus; and FIG. 2B is a graph showing the relationship between the height from the tank bottom surface and the ink density (pigment density, content density).

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FIG. 3 is a schematic perspective view showing the first embodiment of the liquid storage container adopting the present invention.

FIG. 4 is a schematic exploded perspective view  
5 showing the schematic configuration of the liquid storage container of FIG. 3.

FIG. 5 is an enlarged vertical sectional view showing the detailed structure of the connecting unit of the liquid storage container shown in FIGS. 2A, 2B  
10 to 4.

FIG. 6A is a schematic diagram showing the internal state wherein the ink liquid level is sufficiently high in the liquid storage container of FIGS. 2A, 2B; and FIG. 6B is a graph showing the  
15 ratio of the ink amount passing through each liquid inlet hole of the ink agitating chamber at the time of supplying the ink.

FIG. 7A is a schematic diagram showing the internal state wherein the ink liquid level is  
20 lowered to the middle height by the ink consumption from the state of FIGS. 6A, 6B; and FIG. 7B is a graph showing the ratio of the ink amount passing through each liquid inlet hole of the ink agitating chamber at the time of supplying the ink.

25 FIG. 8A is a schematic diagram showing the internal state wherein the ink liquid level is lowered to about 20% of the initial stage by further



consumption of the ink from the stage of FIGS. 7A,  
7B; and FIG. 8B is a graph showing the ratio of the  
ink amount passing through each liquid inlet hole of  
the ink agitating chamber at the time of supplying  
5 the ink.

FIG. 9 is a schematic perspective view showing  
a second embodiment of the liquid storage container  
adopting the present invention.

FIG. 10 is a schematic exploded perspective  
10 view showing the schematic configuration of the  
liquid storage container of FIG. 9.

FIG. 11 is a vertical sectional view showing an  
ink supply system in a third embodiment of the ink  
jet recording apparatus according to the present  
15 invention.

FIG. 12 is a cross sectional view showing an  
experiment apparatus for confirming the effect of the  
present invention.

FIG. 13 is a graph showing the density variance  
20 of the ink.

FIG. 14 is a vertical sectional view showing  
the main tank of the ink supply system in a fourth  
embodiment of the ink jet recording apparatus  
according to the present invention.

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#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, with reference to the drawings,

the embodiments of the present invention will be explained specifically.

FIG. 1 is a perspective view showing a recording apparatus capable of mounting a liquid storage container of the present invention. In FIG. 1, an ink jet recording apparatus for recording an image by ejecting an ink onto a recording medium S having a recording head 1 for ejecting the ink on a carriage 2, conveys the recording medium S in the conveying direction A (sub scanning direction) by a conveying roller 3, and moves the carriage reciprocally in the direction B orthogonal to the sub scanning direction (main scanning direction). The recording medium S is conveyed in the sub scanning direction by a predetermined pitch by the conveying roller 3 such that the scanning operation is executed by the carriage 2 in the main scanning direction while ejecting the ink from the recording head 1 per each pitch of the recording medium S.

A plurality of nozzle rows comprising ejecting nozzles in series in the sub scanning direction are provided on the surface of the recording head 1 facing the recording medium S so as to eject the different inks for each nozzle row. A set of ink supply system is provided for each color nozzle row. The ink supply system comprises a main tank (liquid storage container) 4 for storing the ink, an ink

supply unit 5 for supporting the main tank (liquid storage container) 4, and an ink supply tube 6 for guiding the ink from the ink supply unit 5 to the nozzle row. The ink supply unit 5 supplies the ink  
5 from the main tank (liquid storage container) 4 to the ink supply tube 6.

The ink jet recording apparatus is provided with a recovery unit 7 at a position facing the nozzle surface of the nozzle rows outside the paper  
10 passing range in the main scanning direction. The recovery unit 7 vacuums forcibly the ink and the air from the ejecting nozzle surface for cleaning the ejecting nozzle or filling the ink to be described later.

15 (Embodiment 1)

FIG. 2A is a schematic diagram showing the schematic configuration of an ink supply system in the case of using a first embodiment of a liquid storage container adopting the present invention as  
20 the ink tank of the ink jet recording apparatus; and FIG. 2B is a graph showing the relationship between the height from the tank bottom surface and the ink density. FIG. 3 is a schematic perspective view showing the first embodiment of the liquid storage  
25 container adopting the present invention. FIG. 4 is a schematic exploded perspective view showing the schematic configuration of the liquid storage

container of FIG. 3.

FIG. 5 is an enlarged vertical sectional view showing the detailed structure of the connecting unit of the liquid storage container shown in FIGS. 2A, 2B to 4. FIG. 6A is a schematic diagram showing the internal state wherein the liquid level (ink liquid level) is sufficiently high in the liquid storage container of FIGS. 2A, 2B; and FIG. 6B is a graph showing the ratio of the ink amount passing through each of a plurality of liquid inlet holes of the agitating chamber (ink agitating chamber) at the time of supplying the liquid (ink). FIG. 7A is a schematic diagram showing the internal state wherein the liquid level is lowered to about 50% of the initial stage by the ink consumption from the state of FIGS. 6A, 6B; and FIG. 7B is a graph showing the ratio of the ink amount passing through each liquid inlet hole of the agitating chamber at the time of supplying the ink. FIG. 8A is a schematic diagram showing the internal state wherein the liquid level is lowered to about 20% of the initial stage by further consumption of the ink from the stage of FIGS. 7A, 7B; and FIG. 8B is a graph showing the ratio of the ink amount passing through each liquid inlet hole of the ink agitating chamber at the time of supplying the ink.

In FIGS. 2A, 2B to 8A, 8B, a liquid storage

container 1000 adopting the present invention is mounted and used in a posture with connecting openings 150, 151 of a connecting unit 100 oriented downward. Therefore, the connecting unit 100 side  
5 having the connecting openings 150, 151 is the bottom part of the liquid storage container 1000. Thus, as shown in FIG. 2A, in the case the liquid storage container 1000 is the ink tank of the ink jet recording apparatus, it is mounted on the mounting  
10 part (ink supply unit of FIG. 1) of the ink jet recording apparatus in a stage with the connecting openings 150, 151 oriented downward so as to be used for supplying the ink to the ink jet head (recording head) as the recording means of the ink jet recording  
15 apparatus.

As shown in FIG. 3, the liquid storage container 1000 comprises a liquid storage part (ink storage part) 200 for storing a liquid (ink), a connecting unit 100 for taking out the liquid in the  
20 container main body 200, an information memory medium unit 300 for taking out various kinds of the information on the liquid storage container 1000, and a cap member 400. The liquid storage part 200 is a hollow container produced by blow molding of a  
25 plastic material. The connecting unit 100 has a plurality of connecting parts for inserting through a liquid supplying hollow needle and an atmosphere

guiding hollow needle. The connecting unit 100 is pressured and clamped against an opening part 201 formed in the liquid storage part 200 via a sealing member 101 (see FIG. 4) in the airtight state. The  
5 cap member 400 is screwed (fastened) into a male screw part in the outer circumference of the opening part 201 for pressuring and clamping the connecting unit 100 against the opening part 201 via the sealing member 101. The information memory medium unit 300  
10 is positioned and fixed on the side surface of the liquid storage part 200 by ultrasonic welding, or the like.

Next, with reference to FIGS. 4 and 5, the connecting unit 100 will be explained in detail. The  
15 connecting unit 100 having the plurality of the connecting part comprises integrally a housing 102 having communicating holes 153, 154 formed at a position corresponding to the connecting openings 150, 151 communicating with each connecting part, two  
20 elastic members 103 made of a rubber-like elastic material mounted at a position corresponding to the communicating holes 153, 154 in the housing 102, a pressuring member 104 having communicating holes 155, 156 formed at a position corresponding to the  
25 connecting openings 150, 151, two absorbing members 105 disposed in the pressuring member 104, an absorbing member cover 106 mounted on the outside of

the absorbing members 105, and a cylindrical ink  
agitating chamber 107 provided with a plurality of  
holes 107a, 107b, 107c, 107d, 107e, 107f, 107g in the  
cylinder side surface, and a hole 107h in the  
5 cylinder ceiling.

Accordingly, the liquid storage container 1000  
comprising the liquid storage part 200 having the  
opening 201, and the connecting unit 100 having the  
connecting part for guiding (taking out) the liquid  
10 from the liquid storage part and the connecting part  
for guiding the air into the liquid storage part,  
with the elastic members 103 supported at the  
connecting part in the compressed state, is provided  
as a combination of the liquid storage part 200 and  
15 the connecting unit 100.

The connecting openings 150, 151 are formed in  
the absorbing member cover 106. Moreover, the  
pressuring member 104 is clamped on the housing 102  
by fixing by ultrasonic welding or by an engaging  
20 nail (not shown), or the like.

The elastic members 103 having a dome-like  
shape, are compressed and fixed by the pressuring  
member 104. That is, since the elastic members 103  
are made of a dome-like shaped rubber-like elastic  
25 material, they can be mounted each in the two recess  
parts of the housing 102 so as to be compressed and  
fixed by the pressuring member 104 for generating the

compression force of the elastic members 103 in the radial direction and mounting in the airtight sealed state.

Moreover, the two absorbing members 105  
5 disposed in the pressuring member 104 are clamped (stopped) by the absorbing member cover 106. The absorbing member cover 106 is fixed on the pressuring member 104 or the housing 102 by ultrasonic welding or by an engaging nail (not shown), or the like.  
10 Furthermore, the ink agitating chamber 107 is fixed on the housing 102 by ultrasonic welding, or by an engaging nail (not shown), fitting, or the like. Accordingly, the connecting unit 100 is provided.

As shown in FIG. 5, the connecting unit 100 is  
15 fixed on the opening part 201 of the liquid storage part (container main body) 200 in the sealed state by screwing the cap member 400 having an inner screw into the outer circumference screw of the opening part 201 via the sealing member 101.

20 Then, at the time of using the liquid storage container 100, as shown in FIG. 5, a supply needle 528 and an air guiding needle 529 communicate with the ink agitating chamber 107 and the container main body 200 while piercing through the connecting  
25 openings 150 151, the absorbing members 105, 105, the communicating holes 155, 156, the elastic members 103, 103 and the communicating holes 153, 154 so that the



ink supply path and the atmosphere guiding path are connected via the connecting unit 100 so as to execute a predetermined function (ink supply, or the like). That is, a plurality of connecting part,  
5 communicating with the plurality of the connecting openings 150, 151 is formed in the connecting unit 100. The liquid supply needle 528 is for guiding out the liquid in the liquid storage part 200, and the air guiding needle 529 is for guiding the air into  
10 the container main body 200.

In FIG. 5, the top surface of the cap 400 is opened as shown in the figure. Therefore, the connecting openings 150, 151 formed in the outer side end face (absorbing member cover 106) of the  
15 connecting unit 100 are exposed even in the state being fixed on the connecting unit 100 by the cap 400. The cap 400 is screwed (fastened) by the screw engagement with the opening part 201 of the liquid storage part (container main body) 200. In the inner  
20 diameter part thereof, an engaging part 401 is formed such that the connecting unit 100 can be clamped between the opening part 201 and the cap 400.

The sealing member 101 is compressed by a predetermined amount between a ring-like stepwise  
25 part 157 formed in the outer circumference of the housing 102 of the connecting unit 100 and the opening part 201 of the container main body (liquid

storage part ) 200 by screwing (fastening the cap 400  
such that the inside of the ink tank 1000 can be  
maintained in the airtight state. That is, as shown  
in FIG. 5, in the housing 102 of the connecting unit  
5 100, the engaging surface (stepwise part) 157 is  
formed in the top end surface of the opening part of  
the container main body 200 so that the assembly can  
be enabled in the certain sealed state by clamping  
the sealing member (ring-like sealing member) 101 by  
10 a predetermined compression force in the ring-like  
groove formed in the outer circumference of the  
housing 102.

Next, the information memory medium unit 300  
will be explained. In FIG. 4, the information memory  
15 medium unit 300 comprises an information memory  
medium holder 301, an information memory medium 302  
positioned and fixed on the inner surface of the  
recess part of the information memory medium holder  
301 by a double side adhesive tape 303, and a comb  
20 teeth-like ID part (mechanical identifying part)  
comprising a plurality of projections 304 projecting  
from the outer surface of the information memory  
medium holder 301.

First, the information memory medium 302 will  
25 be explained. The information memory medium 302 can  
exchange the information with the ink jet recording  
apparatus in a state with the ink tank (liquid

storage container) 1000 mounted on an ink jet recording apparatus. The information exchanged between the information memory medium 302 and the ink jet recording apparatus is, for example, information on the ink use period, the ink amount in the ink tank 1000, the ink color, or the like. By taking out the information by the control part of the ink jet recording apparatus, replacement of the ink tank can be advised to the user by outputting the alarm for the use period or the ink exhaustion, or the like. Thereby, a process of preventing generation of the influence of discoloration or thickening of the ink on the recorded image, and a process of preventing generation of the recording failure due to a recording operation in a state with the ink tank holding an ink of a wrong color mounted inadvertently, or the like can be executed. Accordingly, a recording operation can be executed always preferably so that a high grade image output can be obtained.

As the information memory medium 302, any one such as a flash memory, and a write at once magnetic medium can be used as long as it is a medium capable of obtaining the identification information by various kinds of information obtaining means such as magnetic, optical magnetic, electric, and mechanical. According to the ink tank 1000 of this embodiment, as a medium capable of adding the memory information

from the recording apparatus main body side, changing  
or deleting the memory information, in addition to  
maintaining the ink tank identification information,  
and writing of the information from the recording  
5 apparatus main body side, an EEPROM capable of having  
an electric writing and erasing process. The EEPROM  
is mounted on a printed circuit board having a  
connecting part to be electrically connected with an  
electric signal connector provided on the recording  
10 apparatus main body side, with these elements  
provided integrally, the information memory medium  
302 can be provided.

Next, the above-mentioned comb teeth-like  
projection 304 is used for the ID for preventing the  
15 mounting error of the ink tank. The ink tanks are  
cut for a predetermined part for each ink color, for  
the kind of the recording apparatus, or the like.  
The projections are provided at a position on the  
main body side, corresponding to the cut part of the  
20 ink tank so that only the correct ink tank (kind,  
color, or the like) can be mounted. In addition to  
the above-mentioned mounting error prevention by the  
information memory medium, the mounting error can be  
prevented by the mechanical configuration.

25 Next, an example of the ink supply system  
(recording liquid supply system) of the ink jet  
recording apparatus with the liquid storage container

(ink tank) 1000 of this embodiment connected will be explained with reference to FIG. 2A. FIG. 2A is a schematic diagram showing the entire schematic configuration of the recording liquid supply system for recording by connecting the liquid storage container 1000 with the ink jet head (recording head) 524 as the recording means via the connecting unit 100, and jumping the ink from the ink jet head onto the recording medium.

10       The recording head (ink jet head) 524 as the recording means is ink jet recording means for ejecting the ink, utilizing the thermal energy, and it comprises an electro thermal converting member for generating the thermal energy. Moreover, the recording means (recording head) 524 is for recording by generating the film boiling in the ink by the thermal energy applied by the electro thermal converting member, and ejecting the ink from the ejecting opening, utilizing the pressure change by the growth and contraction of the bubbles generated at the time.

In FIG. 2A, the recording head (ink jet head) 524 is connected fluidally with the ink tank 1000 via the ink supply pipe 526. The top end on the ink tank 1000 side of the ink supply pipe 526 is connected with the buffer chamber 530 of the ink supply unit 525. The ink supply unit 525 is provided with the

hollow ink supply needle (ink guiding out needle) 528 communicating with the buffer chamber 530 and the air guiding needle 529. The ink supply needle 528 for guiding out the liquid (ink) from the liquid storage part (ink storage part) 200 elongates (extends) in the ink storage part (container main body) 200 while piercing through the elastic member 103 disposed corresponding to the first fluid connecting part 150 of the ink tank 1000 such that the ink in the liquid storage part (container main body) 200 can be taken out and supplied (guided out) through the needle hole opened in the vicinity of the top end. At the time, since the elastic member 103 is compressed and fixed as mentioned above, by pressuring the outer circumference of the pierced through ink supply needle 528, the airtight property in the periphery of the ink supply needle 528 can be maintained so that the ink leakage can be prevented.

Moreover, the ink supply unit 525 is provided with the air guiding needle 529 communicating with the buffer chamber 530. Like the above-mentioned ink supply needle 528, the air guiding needle 529 elongates into the ink storage part 200, piercing through the elastic member 103 disposed corresponding to the second fluid connecting opening 151 of the ink tank 1000 for guiding the air (atmospheric pressure) into the ink storage part 200 through the needle hole

opened in the vicinity of the top end.

At the time, since the elastic member 103 is compressed and fixed as mentioned above, the airtight property in the periphery of the air guiding needle  
5 529 is maintained by pressuring the outer circumference of the pierced through air guiding needle 529.

The buffer chamber 530 is provided with the buffer chamber air communicating part 527  
10 communicating with the outside of the ink supply unit 525 from the upper part thereof. The air guiding needle 529 elongates to the middle in the height direction of the buffer chamber 530, and the ink guiding out needle (ink supply needle) 528 elongates  
15 to the downward of the air guiding needle 529. In the ordinary state, the inside of the buffer chamber 530 is filled with the ink to the lower end position of the air guiding needle 529 in a state with the buffer space generated in the upper part.

20 Next, with reference to FIG. 2A showing the ink supply system of the ink jet recording apparatus, the liquid storage container 1000 according to the first embodiment explained with reference to FIGS. 3 to 5 will be explained for the ink guiding out operation  
25 (ink supply operation) at the time of taking out the ink for the use as the ink tank. The ink guiding out operation and the detailed explanation for the parts

directly related with the characteristic configuration of the present invention will be described later.

In FIG. 2A, the ink jet head 524 executed a  
5 recording operation by ejecting the ink from the  
ejecting opening 82 formed in the ink ejecting  
opening surface 81 on a recording medium (paper, or  
the like). Then, the ink is supplied from the ink  
tank 1000 to the ink jet head 524 via the ink supply  
10 pipe 526 for complementing the ejected ink.

The ink supply pipe (it may be in the halfway  
thereof) connecting the connecting unit 100 and the  
recording head 524 is provided with the ink supply  
unit 525. In the case the ink in the ink storage  
15 part 200 is reduced according to the ink supply, the  
pressure in the ink storage part 200 is lowered.  
Then, the air to be guided from the buffer chamber  
air communicating part 527 provided in the ink supply  
unit 525 to the buffer chamber 530 is guided into the  
20 ink storage chamber through the air guiding needle  
529.

Here, according to the ink jet recording  
apparatus, the ink to be supplied to the ink jet head  
524 should be maintained in a predetermined negative  
25 pressure state. In the case of the ink supply system  
of this embodiment, the lower end opening of the air  
guiding needle 529 for guiding the air into the tank



main body (container main body) 200 is disposed at a position lower than the ejecting opening surface 81 of the ink jet head 524 such that the height difference (head difference  $h$ ) of the lower end opening of the air guiding needle 529 and the ejecting opening surface 81 functions to the ejecting opening 82 of the ink jet head 524 always as a negative pressure. That is, regardless of the liquid level height of the ink in the ink tank 1000, a substantially constant negative pressure is always applied to the ejecting opening 82 of the ink jet head 524.

Next, with reference to FIG. 2A, the case with the air in the liquid storage part 200 expanded or contracted by the environment change such as the temperature and the pressure will be explained. At the time the air in the liquid storage part 200 is expanded, the liquid (ink) is pushed out into the buffer chamber 530 via the air guiding pipe (needle). The buffer chamber 530 has a sufficient content so as not to overflow the ink from the buffer chamber even in the case the imaginable environment change is generated. Moreover, even in the case a light amount of the ink is overflowed, the ink is absorbed by the waste ink absorbing member (not shown) provided at the top of the buffer chamber air communicating part 527 so that the other parts in the recording

apparatus cannot be polluted with the ink. In contrast, in the case the air in the liquid storage part 200 is contracted, the air (outside air) is guided into the ink tank via the hollow air guiding  
5 needle 529 and the agitating chamber 107.

Although the configuration of guiding the air from the air guiding needle 529 is shown in this embodiment as the configuration of compensating the pressure decline in the ink storage part 200  
10 accompanied by the ink supply to the ink jet head 524, it is also possible that the second connecting opening (air guiding connecting opening) 151 of the connecting unit 100 is connected with a system for supplying a liquid in a constant pressure condition  
15 for supplying the ink (liquid) for compensating the pressure decline. The liquid (ink) in this case may be the same kind of the liquid as the liquid (ink) stored in the ink storage part (container main body) 200.

20 Then, the liquid storage container 1000 according to the embodiment adopting the present invention, comprises the liquid storage part 200 for storing the liquid such as the ink, the liquid taking out connecting part (connecting part communicating  
25 with the connecting opening 150) provided in the bottom part of the liquid storage part, and the agitating chamber 107 provided in the liquid storage

part so as to cover the opening on the liquid storage  
part side of the connecting part, wherein a plurality  
of the liquid inlet holes 107a to 107g each  
communicating with the liquid storage part at a  
5 plurality of positions in the vertical direction are  
formed in the agitating chamber such that the inlet  
resistance of the liquid inlet hole 107a provided in  
the lower layer area on the bottom part side, with  
the content density made thicker than the initial  
10 density in the case the liquid content in the liquid  
storage part is precipitated according to the time  
passage is made larger than the inlet resistance of  
the other liquid inlet holes 107b to 107g out of the  
plurality of the liquid inlet holes of the agitating  
15 chamber.

Hereinafter, with reference to FIGS. 1, 5, 8A  
and 8B, the configuration characteristic of the  
liquid storage container 100 according to the  
embodiment adopting the present invention, and the  
20 effect at the time of precipitating the pigment  
(pigment particle) as the liquid content will be  
explained.

In the case the ink tank 1000 as the liquid  
storage container is left for a long time in a state  
25 mounted on the ink jet recording apparatus, the  
pigment particles as the liquid content are  
precipitated inside the ink tank 1000. FIG. 2B shows

the pigment particle density profile gradually changed according to the vertical direction distance from the bottom surface of the liquid storage part 200. In the ink with the precipitation generated, as  
5 the curve B in FIG. 2B, there is an ink with the pigment particle density changed gradually according to the vertical direction distance from the bottom surface. According to this embodiment, the considerable effect can be expected in the profile of  
10 the curve B.

However, depending on the distribution of the particle size and the particle size distribution of the precipitated particles in the ink, and the ink component, as shown by the curve A in FIG. 2B, there  
15 is an ink having the density inclination of the pigment particles generated from the bottom part to the upper part direction inside the ink tank so as to be separated into a lower layer 603 with the high pigment particle density in the bottom part  
20 (hereinafter, it may also be referred to as the pigment high density layer 603), an upper layer 601 with the low pigment particle density in the upper part (hereinafter, it may also be referred to as the pigment low density layer 601), and a middle layer  
25 602 maintaining substantially the initial pigment particle density (hereinafter, it may also be referred to as the pigment middle density layer 602).

In this embodiment, the maximum effect can be performed for the ink of the curve A of FIG. 2B. Therefore, in the description below, the ink having the profile shown by the curve A in FIG. 2B after the precipitation will mainly be explained.

FIGS. 2A and 6A shows the relationship between the height of the pigment precipitation layers 601, 602, 603, and the height to each of the plurality of the liquid inlet holes 107a, 107b, 107c, 107d, 107e, 107f, 107g provided in the ink agitating chamber 107 at the time the ink amount in the ink tank 1000 is substantially full. Then, the pigment high density layer 603 is provided with the liquid inlet hole 107a out of the plurality of the liquid inlet holes 107a to 107g. Moreover, the pigment middle density layer 602 is provided with the liquid inlet holes 107b, 107c, 107d, 107e, 107f, and the pigment low density layer 601 is provided with the liquid inlet hole 107g.

FIG. 6B shows the ink amount ratio passing through each of the plurality of the holes 107a to 107g of the ink agitating chamber 107 at the time of supplying the ink to the ink jet head 524 in the state of FIG. 6A. Then, as shown in FIG. 6A, the ink is supplied to the out side (to the ink jet head 524, or the like) through the ink supply pipe 526 by printing or vacuuming with a pump in a state with the pigment precipitation, and at the same time, the ink

from each of the pigment high density layer 603, the pigment low density layer 601, and the pigment middle density layer 602 (not from a specific layer) is guided into the agitating chamber 107 through the liquid inlet holes 107a to 107g so as to generate temporary stagnation and mixture in the agitating chamber 107.

Here, according to this embodiment, for restraining the inlet amount of the liquid (ink) by enlarging the inlet resistance (flow resistance) value only for the liquid inlet hole 107a disposed in the lower layer area having the pigment density (content density) thicker than the initial thickness, the hole size of the liquid inlet hole 107a is made smaller than the hole size of the other liquid inlet holes 107b to 107g. For example, the liquid inlet hole 107a is formed as a semi circle hole of  $R = 0.75$  mm, and the liquid inlet holes 107b to 107g are formed as a round hole of a 2 mm diameter. Here, FIGS. 6a, 6B show the inlet ink amount from each of the holes 107a to 107g into the ink agitating chamber 107 at the time the ink is supplied to the printer main body.

Since the inlet amount is as shown in FIG. 6B, and the ink is vacuumed from the ink supply needle 528, the inlet amount from the hole away from the ink supply needle 528 becomes small. Moreover, since the

flow resistance (inlet resistance) of the hole 107a closest to the ink supply needle 528 is made larger as mentioned above, the inlet amount from this hole 107a is small. Therefore, at the item of supplying  
5 the ink, the ink of the most of the total inlet amount (90% in this embodiment) to the ink agitating chamber 107 is supplied from the pigment middle density layer 602, and the inlet amounts from the pigment high density layer 603 and the pigment low  
10 density layer 601 are substantially equal, the ink of the initial pigment particle density can be supplied.

FIGS. 7A, 7B shows the state with the liquid level lowered to the middle position according to the ink consumption from the state of FIGS. 6A, 6B. FIG.,  
15 7A shows the relationship between the height of the pigment precipitation layers 601, 602, 603 in the ink tank and the height of each of the plurality of the holes 107a to 107g provided in the ink agitating chamber 107. The pigment high density layer 603 is  
20 provided with only the hole 107a out of the plurality of the holes 107a to 107g. Moreover, the holes 107b to 107c are disposed at the pigment middle density layer 602, and only the hole 107d is disposed at the pigment low density layer 601.

25 FIG. 7B shows the ink amount ratio passing through each of the holes 107a to 107g at the time the ink is supplied to the ink jet head 524 in the

state of FIG. 7A. In this case, since the liquid level is lower than the hole 107e, the ink is not supplied from the holes 107e to 107g.

Accordingly, in the case the ink is consumed  
5 and the liquid level becomes lower than the hole 107g, the inlet amounts from the pigment high density layer 603 and the pigment low density layer 601 are increased compared with the state of FIGS. 6A and 6B. However, since most of the inlet ink (70% to 80% in  
10 this embodiment) is provided still from the pigment middle density layer 602, and the inlet amount balance from the pigment high density layer 603 and the pigment low density layer 601 is unchanged, the ink of the initial pigment particle density can be  
15 supplied.

FIGS. 8A and 8B show the state with the further ink consumption from the state of FIGS. 7A and 7B so as to have the liquid level lowered to 20% of the initial stage. FIG. 8A shows the relationship  
20 between the height of the pigment precipitation layers in the ink tank and the height to each of the plurality of the holes 107a to 107g provided in the ink agitating chamber 107. Since the hole 107a is disposed at the pigment high density layer 603 out of  
25 the plurality of the holes 107a to 107g, and the pigment middle density layer 602 is substantially used up so that the hole does not exist, and the hole



107b is disposed at the pigment low density layer 601.

FIG. 8B shows the ink amount ratio passing through each hole 107a to 107g at the time the ink is supplied in the state of FIG. 8A. In this case,  
5 since the liquid level is lower than the hole 107c, the ink is not supplied from the higher holes 107d to 107g. As shown in FIGS. 8A, 8B, in the case the liquid level is at a height of about 20% or less of the ink tank container, the ink of the pigment middle  
10 density layer 201 is substantially used up according to the process explained with reference to FIGS. 6A, 6B, 7A, 7B so that the initial pigment density ink can be supplied by agitating the remaining pigment high density layer 603 and pigment low density layer  
15 601 in the ink agitating chamber 107.

According to the embodiment explained above, while paying the attention to the separation of the pigment (liquid content) into the three precipitation layers 601, 602, 603, by agitating and mixing the  
20 thin pigment density layer 601 and the thick layer 603 finally after first using up the ink maintaining the conventional pigment density (pigment middle density layer 602), the liquid storage container 1000 capable of preventing the density difference  
25 generation of the degree visibly observable in the recorded matter even at the time of use over a long period, and capable of supplying the ink of the

initial density to the printer main body, that is, the liquid storage container 1000 using a pigment as the coloring agent, capable of preventing the density variance while recording can be provided.

5 (Embodiment 2)

FIG. 9 is a schematic perspective view showing a second embodiment of the liquid storage container adopting the present invention. FIG. 10 is a schematic exploded perspective view showing the  
10 schematic configuration of the liquid storage container of FIG. 9. With reference to FIGS. 9 and 10, another embodiment (second embodiment) of the liquid storage container adopting the present invention will be explained.

15 In FIGS. 9, 10, the second embodiment of the liquid storage container 1000 adopting the present invention is also to be used while being mounted in a posture with the connecting openings 150, 151 of the connecting unit 100 disposed downward. Therefore,  
20 the connecting unit 100 side having the connecting openings 150, 151 is the bottom part of the liquid storage container 1000. That is, in the case the liquid storage container 1000 is the ink tank of the ink jet recording apparatus, it is mounted detachably  
25 on the mounting part of the ink jet recording apparatus with the connecting openings 150, 151 disposed downward so as to be used for supplying the

ink to the ink jet head as the recording means of the ink jet recording apparatus.

In FIGS. 9, 10, the liquid storage container 1000 comprises the liquid storage part (ink storage part) 200 for storing the liquid (ink), the  
5 connecting unit 100 for taking out the liquid in the liquid storage part 200, the information memory medium unit 300 for taking out various kinds of the information concerning the liquid storage container  
10 1000, and a guard member 420. In this embodiment, the liquid storage container 200 comprises a flat hollow container produced by blow molding of a plastic material. This is for saving the space (miniaturization) of the appliance in the case of  
15 mounting a plurality of the liquid storage containers (ink tank) in the appliance such as a recording apparatus.

The connecting unit 100 having the plurality of the connecting part comprises integrally a housing  
20 102 having communicating holes formed at a position corresponding to the connecting openings 150, 151 communicating with each connecting part, two elastic members 103 made of a rubber-like elastic material mounted at a position corresponding to the  
25 communicating holes in the housing 102, a pressuring member 104 having communicating holes formed at a position corresponding to the elastic members 103,

two absorbing members 105 disposed in the pressuring member 104, an absorbing member cover 106 mounted on the outside of the absorbing members 105. Also in this embodiment, the connecting openings 150, 151 are  
5 formed in the absorbing member cover 106.  
Furthermore, in this embodiment, an ink agitating chamber 107 disposed inside the liquid storage part 200 is provided so as to cover the opening part on the liquid storage part 200 inner side of the  
10 connecting unit 100.

As in the case of the above-mentioned first embodiment, the above-mentioned cylindrical ink agitating chamber 107 comprises a plurality of holes 107a, 107b, 107c, 107d, 107e, 107f, 107g in the  
15 cylinder side surface, and a hole 107h in the cylinder ceiling.

Accordingly, in this embodiment, substantially similarly in the case of the liquid storage container 1000 according to the first embodiment explained with  
20 reference to FIGS. 2A, 2B to 8A, 8B, the liquid storage container 1000 comprising the liquid storage part 200 having the opening 201, the connecting unit 100 having the connecting part for guiding the liquid from the liquid storage part 200 and the connecting  
25 part for guiding the air into the liquid storage part 200, and the ink agitating chamber 107 covering the opening part on the liquid storage part 200 inner

side of the connecting unit 100, is provided as a combination thereof.

Furthermore, according to the second embodiment, the pressuring member 104 and the ink agitating  
5 chamber 107 are clamped on the housing 102 by fixing by ultrasonic welding, or by an engaging nail, or the like. The elastic members 103 having a dome-like shape, are compressed and fixed in the housing 102 by the pressuring member 104. Moreover, the two  
10 absorbing members 105 disposed in the pressuring member 104 are clamped (stopped) by the absorbing member cover 106. The absorbing member cover 106 is fixed on the pressuring member 104 or the housing 102 by ultrasonic welding or by an engaging nail, or the  
15 like. Accordingly, the integrated connecting unit 100 is provided. The connecting unit 100 is fixed on the liquid storage part 200 by ultrasonic welding of the housing 102 onto the bonding surface of the opening part 201.

20 Furthermore, the liquid storage container 1000 of the second embodiment is provided in a hooking stopping structure of hooking the guard member 420 by engaging a projecting hook part elastically deformable with respect to the bottom surface of the  
25 liquid storage part 200 and an engaging hole to be engaged with the hook part after fixing the connecting unit 100 (including the ink agitating

chamber 107) onto the liquid storage part 200 so that the connecting unit 100 can be protected by the guard member 420.

The guard member 420 is provided for the  
5 purpose of protecting the welded connecting unit 100, and protecting and supporting the information memory medium unit 300. Moreover, a mechanical ID comprising comb teeth-like projections is provided for preventing the mounting error of the liquid  
10 storage container 1000 at the longitudinal direction end part of the guard member 420 for the same purpose as in the above-mentioned first embodiment.

The liquid storage container 1000 according to the second embodiment has the substantially same  
15 configuration as in the case of the first embodiment explained with reference to FIGS. 2A, 2B to 8A, 8B in the other aspects. That is, the second embodiment differs from the above-mentioned first embodiment mainly in the following points.

20 First, the liquid storage part 200 comprises the flat container shown in the figure so that the space of the appliance can be saved (miniaturization) in the case of mounting a plurality of the liquid storage containers (ink tanks) on an appliance such  
25 as a recording apparatus.

Second, since the integrated connecting unit 100 is fixed on the liquid storage part 200 by

ultrasonic welding, or the like the members  
corresponding to the sealing member 10 and the cap  
member 400 in the above-mentioned first embodiment  
can be omitted so that further simplification of the  
5 structure and reduction of the number of the parts  
can be achieved.

Third, in the second embodiment, the guard  
member 420 is provided in a hooking stopping  
structure of the projecting hook part elastically  
10 deformable with respect to the bottom surface of the  
liquid storage part 200 and the engaging hole to be  
engaged with the hook part so that the connecting  
unit 100 and the information memory medium unit 300  
can be protected and supported by the guard member  
15 420, and the mechanical ID comprising the comb teeth-  
like protections for preventing the mounting error of  
the liquid storage container 1000 is formed.

Therefore, according to the second embodiment,  
the same effects as in the case of the first  
20 embodiment can be achieved.

Although an example of the case of having the  
two connecting parts in the connecting unit 100 has  
been explained in the above-mentioned embodiment, the  
present invention can be adopted similarly in the  
25 case of providing three or more connecting parts in  
the connecting unit so as to obtain the same effects,  
and this is also included in the scope of the present

invention.

Moreover, it is adopted similarly in the one connecting opening for alternately supplying the ink and introducing the atmosphere so as to obtain the same effects, and this is also included in the scope  
5 of the present invention.

Moreover, although an example of the case of having a round horizontal cross sectional shape of the ink agitating chamber 107 has been explained in  
10 the above-mentioned embodiment, as the cross sectional shape of the connecting unit, an optional shape such as a longer circle, a triangle, and another polygon can be adopted as needed.

(Embodiment 3)

15 FIG. 11 is a vertical sectional view showing an ink supply system in a third embodiment of the ink jet recording apparatus according to the present invention. FIG. 12 is a cross sectional view showing an experiment apparatus for confirming the effect of  
20 the present invention. FIG. 13 is a graph showing the density variance of the ink.

First, the ink to be used in this embodiment will be explained.

As the ink suitable for this embodiment, a  
25 water based ink comprising water insoluble or hardly soluble coloring material dispersed in a water based medium, can be presented. The coloring material is a



substance having the nature of providing the color to an object, and a dispersion dye, a metal complex salt dye, a pigment, or the like can be used.

As the compound for dispersing the coloring  
5 material in the water based medium, a dispersing agent, a surfactant, a resin dispersing agent, or the like can be presented. As the dispersing agent and the surfactant, an anion based one, a nonion based one, or the like can be presented. As the resin  
10 dispersing agent, a styrene and a derivative thereof, a vinyl naphthalene and a derivative thereof, an acrylic acid and a derivative thereof, or the like can be presented. It is preferable that these resin dispersing agents are an alkaline soluble resin  
15 soluble in an aqueous solution with a base dissolved.

As the pigment, in addition to the inorganic pigments such as the ultra marine, the titanium oxide, and the thenard's blue, the organic pigments such as the diazo yellow, the disazo orange, the permanent  
20 carmine FB, the phthalocyanine blue, the phthalocyanine green, and the thioindigo violet can be presented, but it is not limited to these pigments.

Next, with reference to FIG. 11, the liquid discharge recording apparatus and the liquid storage  
25 container according to this embodiment will be explained.

In FIG. 11, a recording head 1 comprises a

liquid connector inserting opening 1a to be connected  
airtight with an ink supply tube 6, and a sub tank 1b  
for accumulating a certain amount of the ink such  
that the ink supplied from the liquid connector  
5 inserting opening 1a is maintained in the sub tank 1b.  
The ink in the sub tank 1b is supplied to an ejecting  
nozzle 1g while successively passing through a filter  
1c and a liquid chamber 1f.

A pressure adjusting chamber 1h is provided on  
10 the upper surface of the sub tank 1b such that the  
sub tank 1b and the pressure adjusting chamber 1h  
communicates with each other by an upper surface  
opening hole 1y. Moreover, the channel elongating  
(extending) from the liquid connector inserting  
15 opening 1a to the ejecting nozzle 1g is maintained in  
a state airtight with respect to the atmosphere.

The ejecting nozzle 1g is a minute cylindrical  
member having about a 20  $\mu\text{m}$  nozzle size. A heater  
(not shown) to generate the heat selectively  
20 according to a command of a CPU is provided inside  
the cylinder. In the case heat is generated by the  
heater, the dissolved air in the ink in contact with  
the heater is expanded and generates bubbles so as to  
push out the ink in the ejecting nozzle 1g so as to  
25 eject the ink. After the ejection, the inside of the  
ejecting nozzle 1g is filled with the ink by the  
capillary tube force of the ejecting nozzle 1g. In

general, a cycle of the ink ejection is repeated at a high speed of 20 KHz or more so as to form a minute image at a high speed.

Although the inside of the ejecting nozzle 1g  
5 is maintained at a negative pressure, in the case the negative pressure is weakened to about the atmospheric pressure, if a pollution or ink droplets are adhered on the top end of the ejecting nozzle 1g, the ink meniscus in the ejecting nozzle 1g is  
10 deteriorated so that the ink can be leaked out.

In contrast, in the case the negative pressure is too strong, the force of drawing back the ink into the ejecting nozzle 1g becomes stronger than the ejecting force so as to cause the ejection failure.  
15 Therefore, the negative pressure in the ejecting nozzle 1g needs to be maintained in a constant range slightly lower than the atmospheric pressure. Although the negative pressure range differs depending on the ejecting nozzle type, that is, the  
20 ejecting nozzle shape, the heater performance, or the like, in this embodiment, it is provided in a range of -40 mmAq (about 0.004 atm) to -200 mmAq (about 0.020 atm) according to the experiment result. In the experiment, the ink specific gravity was provided  
25 substantially equal to the water specific gravity.

The filter 1c is provided for the purpose of eliminating the foreign substances, which may choke

the ejecting nozzle 1g, and it scavenges the foreign substances by a metal mesh of 10  $\mu\text{m}$  or less smaller than the nozzle size of the ejecting nozzle 1g.

The filter 1c area is set sufficiently large so  
5 that the ink pressure loss can be at a tolerance value or less. The pressure loss becomes higher with a smaller mesh size of the filter 1c, and a higher ink flow rate, and in contrast, it is counter proportional to the filter area. The high speed, the  
10 larger number of nozzles and the minute dots in the recent ink jet recording apparatus lead to the tendency of increasing the pressure loss so that the filter 1c size becomes large to about 10  $\times$  20 mm, and thus the space for the sub tank 1b and the liquid  
15 chamber 1f is needed on the upstream side and the downstream side of the filter 1c. As to the ink permeation, since the area of the filter 1c soaked with the ink on the upstream side of the filter 1c becomes the filter effective area, in order to obtain  
20 a sufficiently larger effective area, the filter 1c is disposed horizontally on the bottom part of the sub tank 1b.

In the case the filter 1c is permeated with the ink, minute meniscuses are provided in the mesh so  
25 that the ink can be transmitted while inhibiting the air flow. With a smaller mesh, the meniscus strength becomes higher so that the air can hardly pass

through. According to the filter 1c of this embodiment, the air cannot transmit through the meniscus unless the pressure difference of before and after becomes to about 0.1 atm (experiment value).

5    Thereby, in the case the air is present in the liquid chamber 1f on the downstream side of the filter 1c, the air cannot move up to the sub tank 1b by the pressure of about the floating force of the air itself so as to remain in the liquid chamber 1f.

10   Therefore, the upstream side direction entrance of the air can be prevented.

          In the case the air or the bubbles in the ink enter into the ejecting nozzle 1g, the ink cannot be charged to the ejecting nozzle 1g so as to generate

15   the ejection failure. Therefore, the ejecting nozzle 1g is disposed downwardly in the bottom part of the liquid chamber 1f for accumulating the ink by a certain amount or more so that the upper surface of the ejecting nozzle 1g can always be soaked in the

20   ink without being exposed to the air.

          The pressure adjusting chamber 1h is a room for reducing its capacity as the negative pressure is heightened, comprising an elastic member of a rubber material, or the like. In the case a large amount of

25   the ink per unit time is ejected (hereinafter, it is referred to as the high duty), such as the ink ejection from the all ejecting nozzles 1g, at the

time of passing through the ink supply unit 5 and the ink supply tube 6 from the main tank 4, the pressure loss is generated in the ink so that the pressure in the sub tank 1b is lowered. Thereby, the ink supply amount becomes insufficient with respect to the ink ejection necessary amount so that the negative pressure in the sub tank 1b is raised, and the ejection becomes instable in the case the negative pressure of the ejecting nozzle 1g exceeds the limit value -200 mmAq (about -0.020 atm).

According to the printer for reciprocal printing in the main scanning direction B with the recording head 1 mounted on the carriage 2, since the carriage 2 is inverted after the high duty printing, an ejection pause state exists. The pressure adjusting chamber 1h plays a roll of a capacitor of alleviating the negative pressure rise in the sub tank 1b by the capacity reduction, and recovers the negative pressure to the normal value at the time of the inversion.

Next, the ink supply unit 5 and the main tank 4 will be explained.

The main tank 4 comprising a rigid case 4a provided with two rubber plugs 4b, 4c in the lower part, is detachable with respect to the ink supply unit 5. The main tank 4 is a sealed container as a single body for storing the ink 9 as a liquid.

The ink supply unit 5 is provided with a supply needle 5a, and an atmosphere guiding needle 5b. At the time of mounting on the main tank 4, the supply needle 5a and the atmosphere guiding needle 5b pierce  
5 through the rubber plugs 4b, 4c so that the channel communicating between the inside of the main tank 4 and the supply needle 5a, the atmosphere guiding needle 5b is provided.

In the main tank 4, the supply needle 5a is  
10 inserted to the lower part, and a pipe 4d elongating upward from the rubber plug 4b is provided. In the pipe 4d, a plurality of through holes 4e1 to 4e7 are formed in the circumference facing with each other, with the upper end opened. The pipe 4d will be  
15 explained later.

The ink supply unit 5 is provided with a channel 5d communicating with the ink supply tube 6, a blocking valve 10 for blocking the ink supply to the channel 5d, and a channel 5c elongating from the  
20 supply needle 5a to the blocking valve 10 such that the blocking valve 10 can be opened or closed selectively.

The atmosphere guiding needle 5b communicates with the atmosphere via the channel 5e, the  
25 atmosphere communicating chamber 5f, and the atmosphere communicating opening 5g.

The inner diameter of the supply needle 5a, and

the atmosphere guiding needle 5b is set at a large value of  $\phi 1.6$  (mm) for restraining the ink flow resistance.

The blocking valve 10 opens or closes the  
5 channel by vertically moving a rubber material diaphragm 10a. The central part of the diaphragm 10a is pressured from above by a spring 10c via a spring holder 10b so that the opening of the channel 5d can be closed by the lower surface of the diaphragm 10a.  
10 Thereby, the channel blocking state can be provided.

A flange 10f is provided in the upper part of the spring holder 10b. The flange 10f is engaged with the point of application of a rotatable lever 10d. The lever 10d has the power point contacted  
15 with the link 7b interlocked with the recovery unit 7 to be described later so as to lift up the diaphragm 10a, resisting to the pressuring force of the spring 10c in the case it is pushed by the link 7b so as to have the channel 5c and the channel 5d in the  
20 communicating state.

The blocking valve 10 is in the opened state when the recording head ejects the ink, and in the closed state when it is in the stand by or pose state. It will execute the opening or closing operation by  
25 the timing of the recovery unit 7 at the time of filling the ink to be described later.

The above-mentioned ink supply unit 5 and main



tank 4 configuration is provided for the inks of each color of the black, the cyan, the magenta and the yellow. The supply needle 5a, the atmosphere guiding needle 5b, the channels 5c, 5d, 5e, the blocking  
5 valve 10, and the atmosphere communicating chamber 5f are provided integrally in the ink supply unit 5. The lever 10d of the blocking valve 10 is provided one each for the all inks. The flange 10f of the spring holder 10b in the blocking valve 10 of each  
10 color ink engages with the point of application of the lever 10d so that the blocking valves for each color are opened or closed at the same time.

In the case the recording head 1 consumes the ink, the ink is sent each time from the main tank 4  
15 to the recording head 1 by the negative pressure. At the time, the same amount of the air as the ink is guided from the atmosphere guiding opening 5g to the main tank 4 via the atmosphere communicating needle 5b.

20 The atmosphere communicating chamber 5f temporarily stores the ink pushed out by the air expansion in the main tank 4. In the case the air in the main tank 4 is expanded by the circumferential environment temperature is raised while the ink jet  
25 recording apparatus is in the stand by or pause state, the ink 9 in the main tank 4 flows out from the atmosphere communicating needle 5b to the atmosphere

communicating chamber 5f via the channel 5e. In contrast, in the case the environment temperature is lowered, the air in the main tank 4 is contracted so that the ink flown out into the atmosphere

5 communicating chamber 5f returns to the main tank 4. Moreover, in the case a printing operation is executed in a state with the ink entered in the atmosphere communicating chamber 5f, first the ink in the atmosphere communicating chamber 5f returns to

10 the main tank 4, and when the ink in the atmosphere communicating chamber 5f is run out, the air is guided to the main tank 4 as usual. In the case the capacity of the atmosphere communicating chamber 5f is insufficient, the ink is leaked out from the

15 atmosphere communicating opening. Therefore, by ensuring the capacity of the atmosphere communicating chamber 5f in consideration of the maximum ink flow out amount in a range of the apparatus use environment temperature, the ink leakage can be

20 prevented.

The air maximum expansion volume in the main tank 4 is the expansion volume to have the equal volume as the tank capacity at the maximum temperature. The volume obtained by subtracting the

25 air volume in the main tank 4 at the lowest temperature from the maximum expansion volume is the capacity required for the atmosphere communicating

chamber 5f.

An inverse U shaped part 5k is provided in the channel elongating from the atmosphere communicating chamber 5f to the atmosphere communicating opening 5g.

5 The inverse U shaped part 5k is disposed at a position higher than the upper end opening of the supply needle 5a. In the case the inverse U shaped part 5k is not provided, if the main tank 4 storing the ink 9 is mounted without mounting the recording  
10 head 1 inadvertently and the blocking valve 10 is opened, the air is guided from the supply needle 5a into the main tank 4. Then, the top end of the supply needle 5a has the atmospheric pressure so that the ink flows to the lower part so as to be leaked  
15 out from the atmosphere communicating opening 5g. That is, according to the inverse U shaped part 5k, the ink leakage can be prevented even in the case an operation error of having the inside of the main tank 4 at the atmospheric pressure is generated.

20 The supply needle 5a and the atmosphere communicating needle 5b of the ink supply unit 5 are connected with a detection circuit 5h for measuring the electric resistance of the ink 9 for detecting existence or absence of the ink in the main tank 4.

25 In the case the ink 9 is present in the main tank 4, the supply needle 5a and the atmosphere communicating needle 5b are conducted electrically

(closed). In the case the ink is absent or the tank is not mounted, it is blocked electrically (opened). In the case the opened state is detected, the detection circuit 5h transmits a predetermined signal  
5 to a control unit (not shown). Since the detection electric current is minute, the insulation property between the supply needle 5a and the atmosphere communicating needle 5b is important. In this embodiment, the channel elongating from the supply  
10 needle 5a to the recording head 1, and the channel elongating from the atmosphere communicating needle 5b to the atmosphere opening 5g are provided completely independent with each other so that the electric resistance of only the ink in the main tank  
15 4 can be measured.

In the case the main tank 4 is detached, similar to the case of the ink absence state, the supply needle 5a and the atmosphere communicating needle 5b are in the opened state. At the time, it  
20 is judged to be the ink absence, and a signal showing the printing impossible state is transmitted to the control unit.

Next, the configuration of the inside of the main tank 4 will be explained.

25 The through holes 4e1 to 4e7 of the pipe 4d are disposed zigzag by a predetermined pitch (L1 to L6) along the axis direction of the pipe 4d. The pitches

L1 to L6 are set at the equal pitch or the unequal pitch.

The cross sectional shape of the pipe 4d is provided as for example a round shape, but as long as  
5 it has a predetermined cross sectional area (to be described later) or more, various kinds of shapes such as elliptic, polygonal, abnormal, or the like can be adopted.

The size of the through holes 4e are set such  
10 that the flow amount of the through holes 4e becomes equal in consideration of the pipe inside tube path friction, the enlarged or reduced tube pressure loss, the through hole height (head), or the like. The cross sectional shape of the through holes 4e is  
15 provided as for example, a round shape, however, a counter bore shape having a tapered surface on the through hole outer side opening end (pipe outer circumference side opening end), or the like can also be adopted for reducing the channel resistance. As  
20 long as it is a hole capable of having the equal flow amount, a polygonal or abnormal shape can be used as well.

The upper end opening part height of the pipe 4d is provided upper than the ink liquid level 9a at  
25 the time the main tank 4 is filled with the ink by the maximum amount, and the uppermost part through hole 4e7 position is provided at a position slightly

lower than the liquid level 9a. The position of the lowermost part through hole 4e1 is at the same height as the main tank bottom surface. According to the configuration, the ink stagnation in the main tank 4  
5 can be reduced as much as possible so that the ink can be used up without waste.

As to the through hole 4e arrangement, various arrangements such as arranging on one side of the pipe 4d spirally along the pipe 4d circumference, or  
10 the like. However, in either arrangement, it is preferable that the number of the through holes and the through hole pitch L are set according to the precipitation degree of the ink 9 (the volume ratio of the thick ink at the time of the precipitation).

15 In the case the ink liquid level is lower than the second through hole 4e2, since the ink is supplied only from the lowermost through hole 4e1, the through hole size  $\phi d1$  of the through hole 4e1 should be a size without causing a trouble such as  
20 the bubble generation due to the supply insufficiency. According to the experiment, the through hole size  $\phi d1$  needs to be  $\phi 1$  mm or more. In this embodiment, the thorough hole size of the through holes 4e1 to 4e7 is set at  $\phi 1$  mm to 3 mm.

25 The inner diameter  $\phi D$  of the pipe 4d should be a size without bridging the bubbles in the pipe (bubble choking). The bridge characteristic depends

on the surface tension and the viscosity of the ink 9.  
For example, when the user mounts the main tank 4 on  
the ink supply unit 5 after shaking the same, or the  
like, the bubbles are trapped in the pipe so that the  
5 ink supply is stagnated.

According to the experiment, in order to  
prevent bridging, the pipe cross sectional area needs  
to be 20 mm<sup>2</sup> or more. In this embodiment, in  
consideration of the margin of the ink viscosity  
10 irregularity, or the like,  $\phi D = \phi 8\text{mm}$ . Gradual  
enlargement of the pipe cross sectional area from the  
lowermost part toward the upper end opening part is  
preferable in that not only it can be peeled off from  
the mold at the time of pipe molding, but also the  
15 channel resistance of the pipe length can be  
alleviated so that the through hole size setting  
allowance range can be widened. Moreover, thereby,  
since the hole size  $\phi d_1$  of the lowermost part through  
hole 4e1 can be made larger, the bubble generation by  
20 the supply insufficiency to be described later can  
also be alleviated so that the ink from the through  
holes can be agitated in the pipe, and thus it is  
effective in terms of homogenizing the density. As  
to the taper angle, it is preferably about 1 to 5  
25 degrees.

According to the configuration, even in the  
case the above-mentioned precipitation is generated

by leaving the tank, the substantially same flow amount of the inks flows from the entire area of the upper layer part, the middle layer part and the lower layer part of the main tank into the pipe 4d so as to  
5 be supplied from the supply needle 5a while being agitated in the pipe 4d in a state with the density homogenization.

In order to sufficiently agitate in the pipe 4d with a small ink flow amount, the inner diameter  $\phi D$   
10 of the pipe 4d should be made small as much as possible so that it is provided preferably at the lower limit value with the margin added in a range without the bubble bridge generation.

In FIG. 12, the experiment for confirming the  
15 density homogenization effect by the pipe 4d was executed by the following conditions.

That is, the following density distribution measurement was executed with a pipe 4d inner diameter  $\phi D = \phi 8$  mm, an inner diameter  $\phi d1$  to  $d7$  of  
20 the through holes 4e1 to e7 of  $\phi 1$  mm to 3 mm, and a pitch  $L1$  to  $L6$  of 15 to 20 mm.

For both of the main tank 4 provided with the pipe 4d and the main tank 4 without providing the pipe 4d, the experiment by the procedures (1) to (4)  
25 was executed for twice each.

(1) With the inside of the main tank 4 filled with 250 cc of pure water W, 10 cc of a raw ink 20 (black



ink) was injected slowly from the atmosphere communicating needle 5b side by an injection cylinder 400, or the like.

(2) The pure water including the raw ink 20 (hereinafter it is referred to as the liquid mixture) was vacuumed from the ink supply needle 5a by the vacuuming pump 21 for accelerating the precipitation of the raw ink 20. The flow amount from the ink supply needle 5a at the time was set equal to the real ink flow amount of the ink jet recording apparatus.

(3) The liquid mixture vacuumed by the vacuuming pump 21 was sampled by a predetermined timing.

(4) An appropriate amount of the sampled liquid mixture was dropped onto a test paper 22. After leaving and drying, the OD value (density) of the colored surface 23 was measured.

FIG. 13 is a graph with the time plotted in the lateral axis, and the OD value in the vertical axis. In the graph, the experiment result for the main tank 4 provided with the pipe 4d is shown by the graphs A1 (black triangle plot) and A2 ( $\times$  plot), and the experiment result for the main tank 4 without providing the pipe 4d is shown by the graphs A3 (black round plot) and A4 (black square plot).

While the density is homogeneous in the graphs A1, A2, the density is drastically lowered in the

graphs A3, A4. Thereby, the density homogenizing effect of the pipe 4d can be observed apparently.

In FIG. 11, the recovery unit 7 has a vacuuming cap 7a to be raised toward to the ejecting nozzle 1g at a position facing the ejecting nozzle 1g. The vacuuming cap 7a is driven vertically by the cam 7b. The vacuuming cap 7a made of a rubber material covers and closes tightly the nozzle surface of the ejecting nozzle 1g at the time of being raised, and it is moved to a position withdrawn from the recording head 1 at the time of being lowered. The cam 7b is driven by the cam controlling motor 7g.

The vacuuming cap 7a is connected with the vacuuming pump 7c such that the ink or the air is vacuumed from the inside of the vacuuming cap 7a according to the drive of the pump motor 7d. The vacuuming pump 7c is of the tube pump method having a plurality of rollers. It can vacuum continuously, and it can adjust the vacuuming amount according to the rotation speed of the pump motor. The maximum vacuuming pressure of the vacuuming pump 7c is set at for example 0.4 atm.

The cam controlling motor 7g is interlocked with the cam 7f for driving the link 7e such that the link 7e is driven, interlocked with the vertical movement of the vacuuming cap 7a so as to rotate the lever 10d. Thereby, the blocking valve 10 is opened

or closed, interlocked with the vacuuming cap 7a.

The cam controlling motor 7g rotates and drives the cams 7b, 7f in the arrow Cd direction concentrically. The cams 7b, 7f set the vacuuming cap 7a, the blocking valve 10 at the positions a, b, c of FIG. 1 at a predetermined state. At the position "a", both the vacuuming cap 7a and the blocking valve 10 are in the opened state, at the position "b", both the vacuuming cap 7a and the blocking valve 10 are in the closed state, and at the position c, the vacuuming cap 7a is in the closed state and the blocking valve 10 is in the opened state.

At the time of the image recording operation, the cams 7b, 7f are set at the position "a" so as to open the vacuuming cap 7a and the blocking valve 10 for enabling the ink ejection and the ink supply.

During the apparatus stopping and stand by period, the cams 7b, 7f are set at the position "b" so as to cover the nozzle surface of the recording head 1 by the vacuuming cap 7a for preventing drying of the ejecting nozzle 1g. At the time, the blocking valve 10 is closed so that the ink flow out by the apparatus movement, the apparatus inclination, or the like is prevented.

At the position "b" state of the cams 7b, 7f, the ink charging operation is executed by the

recovery unit 7. At the time of the ink charging operation, the carriage 2 is moved in the main scanning direction, and the recording head 1 is moved to a position facing the vacuuming cap 7a. Next, the  
5 cam controlling motor 7g of the recovery unit 7 is driven so that the cam 7b and the cam 7f are rotated to the position "b". Then, the vacuuming cap 7a is in a state of covering and closely closing the nozzle surface of the recording head 1, and the blocking  
10 valve 10 closes the ink channel. Next, in the case the pump motor 7d is driven for executing the vacuuming operation of the vacuuming pump 7c, the ink and the air stagnating in the recording head 1 is vacuumed out through the ejecting nozzle 1g so that  
15 the pressure inside the recording head 1 is reduced. The vacuuming operation of the vacuuming pump 7c is continued until it reaches at a predetermined pressure (predetermined vacuuming amount), obtained by the calculus or the experiment. At the time the  
20 vacuuming pump 7c is stopped, the cam controlling motor 7g is driven so as to rotate the cam 7b and the cam 7f to the position c, and the blocking valve 10 is opened. Then, the ink flows into the recording head 1 with the reduced pressure so that the sub tank  
25 1b and the liquid chamber 1f are filled with the ink. The ink amount to be filled is the volume necessary at the time of returning the pressure of the chambers

with the reduced pressure substantially to the atmospheric pressure, and it is determined by the volume and the pressure of the chambers. The ink charging operation is completed in about 1 second  
5 after opening the blocking valve 10.

When the ink charging operation is completed, the cam controlling motor 7g is driven so as to rotate the cams 7b, 7f to the position "a", and the vacuuming cap 7a is opened so as to discharge the ink  
10 remaining in the vacuuming cap 7a by the vacuuming pump 7c. Since the blocking valve 10 is in the opened state at the time, the image can be recorded, however, in the case there is no image recording command, the cam controlling motor 7g is driven again  
15 so as to rotate the cams 7b, 7f to the position "b" for being in the stand by state.

(Embodiment 4)

Next, a fourth embodiment of the ink jet recording apparatus according to the present  
20 invention will be explained with reference to the drawings.

FIG. 14 is a vertical sectional view showing the main tank of the ink supply system in the fourth embodiment. The same numerals are provided for the  
25 same or corresponding parts as in the third embodiment, and explanation is omitted here.

In FIG. 14, as in the third embodiment, the

main tank 30 comprising a rigid case 30a provided with two rubber plugs 30b, 30c in the lower part, is detachable with respect to the ink supply unit 31. The main tank 30 is a sealed container as a single  
5 body for storing the ink 32 as a liquid. The main tank 30 is mounted on the ink supply unit 31 by being slid in the arrow Td direction (horizontal direction) in the figure.

In the upper part of the ink supply unit 31,  
10 the atmosphere communicating opening 31a is formed, with the atmosphere communicating opening 31a communicating with the hollow atmosphere guiding needle 31c. The supply needle 31b is provided in the lower part of the ink supply unit 31, with the supply  
15 needle 31b communicating with the recording head 1 via the ink supply tube 33.

At the time of mounting on the main tank 30, the supply needle 31b and the atmosphere guiding needle 31c pierce through the rubber plugs 30b, 30c  
20 so that the channel communicating between the inside of the main tank 30 and the supply needle 30b, the atmosphere guiding needle 30c is provided.

The pipe 30d elongating obliquely upward from the rubber plug 30b is provided inside the main tank  
25 4, and the supply needle 30b is opened toward the inside of the pipe 30d in the lower part of the pipe 30d.

In the pipe 30d, a plurality of through holes 30e1 to 30e7 are formed in the circumference facing with each other, with the upper end opened. As in the third embodiment, the through hole size of the through holes 30e is set such that the flow amounts  
5 can be equal.

As in the third embodiment, the height of the upper end opening part of the pipe 30d is higher than the ink liquid level 32a at the time of filling the main tank 30 with the maximum amount of the ink, and  
10 the position of the uppermost part through hole 30e6 is at a position slightly lower than the liquid level 32a. The position of the lowermost part through hole 30e1 is at the substantially same height as the main tank bottom surface. The bottom part of the main  
15 tank 30 is an inclined surface having a predetermined angle toward the rubber plug 30b. According to the configuration, the ink stagnation in the main tank 30 can be reduced as much as possible so that the ink  
20 can be used up without waste.

As in the third embodiment, the through hole size  $\phi d1$  of the lower most part through hole 4e1 should be a size without causing a trouble in the supply even in the case the ink residual amount  
25 becomes small, and the pipe 30d inner diameter should be a size without bridging the bubbles in the pipe (bubble choking).

According to the fourth embodiment, as in the third embodiment, even in the case the above-mentioned precipitation is generated by leaving the tank, the substantially same flow amount of the inks  
5 flow from each through hole 30e from the entire area of the upper layer part, the middle layer part and the lower layer part of the main tank into the pipe 30d so as to be supplied from the supply needle 30b while being agitated in the pipe 30d in a state with  
10 the density homogenization.

Recently, according to the high speed printing, the large recording paper size, the continuous operation property, or the like, a large capacity is required for the main tank. Although the operativity  
15 of the large capacity main tank tends to be lowered due to the weight increase, according to the configuration of the second embodiment of mounting the main tank 30 by sliding, it can be mounted with a small operation force so that a high operativity can  
20 be achieved.